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THE HUMAN ELEMENT IN SPACE: LESSONS FROM ANTARCTICA

L. A. PALINKAS

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NAVAL HEALTH RESEARCH CENTER
P.O. BOX 85122
SAN DIEGO, CALIFORNIA 92138

NAVAL MEDICAL RESEARCH AND DEVELOPMENT COMMAND
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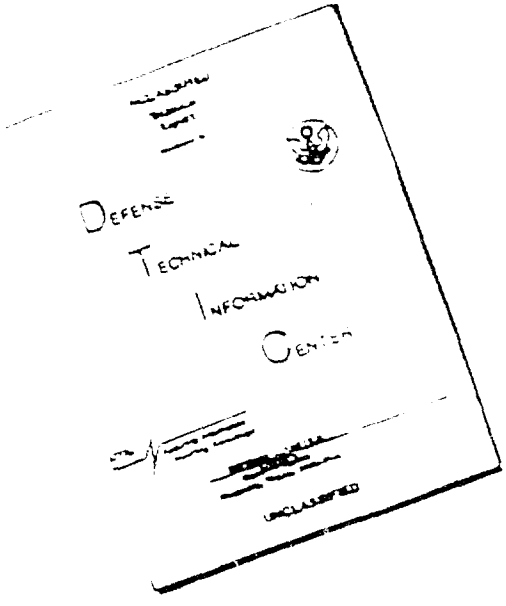

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THE HUMAN ELEMENT IN SPACE: LESSONS FROM ANTARCTICA

Lawrence A. Palinkas, Ph.D.

Occupational Medicine Department

Naval Health Research Center

P.O. Box 85122

San Diego, CA 92138-9174

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SUMMARY

Problem

The ability of humans to adapt and perform in an extreme environment during periods of prolonged isolation is influenced by a number of social, cultural, and psychological parameters. These parameters must be taken into consideration in the design, construction, and operation of space facilities and off-world bases.

Objective

This paper describes the human experience in the Antarctic and examines its relevance to the design and operation of manned space facilities and offworld communities.

Approach

Three components of the human experience in Antarctica are examined: (1) patterns and processes of individual psychological adjustment to prolonged isolation in an extreme environment; (2) the social organization of Antarctic research stations; and (3) the cultural systems of these stations.

Results

Scientists and support personnel who winter-over in Antarctica are subjected to a combination of physiological and psychological changes which are a response to certain inherent features of prolonged isolation in an extreme environment. Among these features are the physical, affective, and cognitive demands of a novel environment; restricted contact and mediated communications with family, friends, and outside authorities; and few opportunities for gratification of social and psychological needs. These stresses affect all personnel to some degree. However, variations in task accomplishment, social compatability, and emotional composure of a confined group are influenced by the personality characteristics of the individual, the

organization of the social group, and the microculture of the station.

Conclusion

The human element in space may be enhanced by altering the environment or developing programs to strengthen the processes of adaptation and adjustment to this environment.

Recommendations

Space stations and offworld communities should be designed to minimize the physical, cognitive, and affective demands of the environment; incorporate communications technology which provides optimal levels of interaction with earth; and provide opportunities for meeting individual needs, minimizing social conflicts, and fulfilling individual, social, and organizational expectations. Screening programs should be focused on best qualified candidates from the standpoint of adaptation to this specific environment. Training programs designed to reduce group tension and improve performance should be encouraged. Cultural systems specifically tailored to facilitate individual adjustment and social interaction in space should be developed.

The Human Element in Space: Lessons from Antarctica

The successful construction and operation of facilities and bases in space ultimately rests with the ability of humans to adapt and perform in an extreme environment during periods of prolonged isolation. Our current understanding of the social, cultural, and psychological parameters of the human element in space is largely based on the experiences of small groups in analog settings. Among the most prominent of these analogs is the human experience in Antarctica. Over the past 30 years, a continuous human presence in the Antarctic has been maintained by several nations in the form of remote scientific research stations. During the austral winter these stations are relatively isolated from the outside world.

This paper describes the human experience in the Antarctic and examines its relevance to manned space facilities and offworld communities. Three components of this experience are addressed: (1) patterns and processes of individual psychological adjustment to prolonged isolation in an extreme environment; (2) the social organization of Antarctic research stations; and (3) the cultural systems of these stations.

Patterns and Processes of Individual Psychological Adjustment

To date, several physiological and psychological changes have occurred among astronaut personnel during extended missions in space. These include the highly publicized space adaptation syndrome (space sickness); bone decalcification; cardiovascular deconditioning; depression; irritability, especially directed towards ground control personnel; and cognitive impairment (Bluth, 1981; Christensen and Talbot, 1986; Conners, et al., 1986; Hillman, 1986). Scientists and support personnel who winter-over in the Antarctic are also subjected to a combination of physiological and psychological changes. Physiological changes include dyspnea, arterial hypoxia, headaches, hypo-

capnia, hyperventilation, suppression of the immune system, hyperthyroidism, a complete absence of Stage IV sleep as well as sizable reductions in the amount of Stage III and REM sleep, and a disruption of circadian rhythms. These are attributed to extreme environmental conditions including high altitude, extreme light-dark cycles, and the absence of viral and bacterial agents.

Similarly, most Antarctic winter-over personnel display a cluster of symptoms known as the "winter-over syndrome." This syndrome is characterized by varying degrees of depression; irritability and hostility; insomnia; and cognitive impairment, including difficulty in concentration and memory, absentmindedness, and the occurrence of mild fugue states known as "long-eye." These symptoms have been observed to increase over time (Gunderson, 1963), peaking at mid-winter, and then declining during the third quarter of winter-over duty, only to increase again at the end of the winter-over period. In some instances, alcohol abuse has been a problem on the ice, leading to disruption of social relations among station personnel, decreased work performance, and increased risk for accidental injury (Blair, 1983). Episodes of severe psychopathology, resulting in confinement of personnel or midwinter evacuation when feasible, have been rare (Strange and Youngman, 1971).

Although many of these symptoms are attributed to the physiological changes experienced by winter-over personnel, the most significant stressors underlying these conditions appear to be psychosocial in nature. Apart from the physiological changes associated with the harshness of the environment, the physical environment appears to have had little impact on the winter-over syndrome. Danger, hardship, or the direct effects of cold have not represented important stressors (Mullin, 1960), nor have improvements in station living conditions significantly reduced the incidence of these symptoms (Gunderson, 1974). However, prolonged isolation in a small community such as

a research station or offworld base carries with it a set of internal and external psychosocial stressors. External sources of stress include the inability to contact family and friends, real or imagined unpleasant events at home, and feelings of rejection resulting from delays in arrival of relief parties, shortages in supplies, and interference with station autonomy by outside authorities and parent agencies. Internal sources of stress include the lack of privacy in cramped quarters, boredom due to the lack of social and environmental stimulation, sexual and emotional deprivation, and the absence of statuses and roles defining one's social position in the outside world or--in the case of space stations and offworld communities--on earth.

Due to the difficulty in evacuating personnel for medical or psychiatric reasons, and in an effort to reduce the impact of these physiological and psychological changes on health and performance on the ice, all U.S. personnel have been routinely screened by teams of Navy psychiatrists and psychologists since the late 1950s. The underlying assumption of this program is that the stress of isolated duty does not induce mental illness in psychiatrically normal people but may exacerbate or make apparent emotional problems that already exist (Strange and Youngman, 1971).

The importance of this screening effort is reflected in the fact that during the first two years of Antarctic screening, the recommendations of the screening teams were entirely disregarded. Half of the members of one station were disqualified by the screening team but sent to the Antarctic anyway. This group was characterized as having more difficulty and conflict among members than any other winter-over group (Oliver, 1979).

There are four primary areas in determining psychiatric suitability of candidates for a winter-over assignment: motivation history of past personal effectiveness, present ego strength and adequacy of defense mechanisms, and adequacy of interpersonal relationships (Nardini, et al., 1962). Overall,

the screening program has been successful in identifying and eliminating individuals who might be totally ineffective under the stress of Antarctic isolation, or who might require hospitalization for a psychiatric disorder. One notable exception to this success has been the inability to exclude personnel who develop problems with substance abuse on the ice. However, while the program has generally been successful in screening out individuals unqualified for winter-over duty, it has been less successful in identifying or "screening in" individuals who are best qualified for such an assignment. Clinical evaluations have not been powerful predictors of Antarctic adjustment (Gunderson, 1974).

Adjustment or adaptation to prolonged isolation in the Antarctic has traditionally been evaluated in terms of work performance, social compatibility, and emotional composure. These dimensions have been measured using ratings of station members provided by peers and station leaders. The best single criterion of effective individual performance at these small stations, however, appears to be a standard score derived from a combination of peer and supervisor choices on an item indicating whom they would prefer to be with if they were to winter-over again in the Antarctic (Gunderson and Nelson, 1963).

On the basis of these adjustment criteria, some characteristics have been found to predict for successful adaptation. For instance, heterogeneity on personality scales generally tends to correlate negatively with the group performance criteria (Gunderson and Ryman, 1967). Individuals who score low on the 16-PF measures of depression and divergent thinking and high on measures for cheerful, trusting, and caution, seem to adjust well to the Antarctic environment. Adjustment also appears to be a function of narrow interests and a low need for stimulation (Biersner and Hogan, 1984).

However, other characteristics, such as age, education, occupational

experience, marital status, and family history, have not been found to be consistently related to adjustment in the Antarctic. Further, biographical attributes and personality measures such as achievement need and job motivation are not equally predictive for all members of a winter-over group. Variables that predict social adjustment for one subgroup of personnel do not predict emotional adjustment for the same subgroup or social adjustment for another subgroup (Gunderson, 1974). The predictive value of any one set of variables, therefore, appears to depend on the individual's status as a civilian or member of the military, his or her occupation in the station, and station size. At large stations, for instance, where recreational and social activities are more varied and plentiful, expressed interest in many avocational activities was found to be positively associated with adjustment, whereas at small stations, where opportunities for recreational activities were very limited, expressed preference for many hobbies and leisure activities was negatively correlated with adjustment (Gunderson, 1974).

Social Organization

Individual patterns and processes of adjustment in the Antarctic occur in a social context and are influenced by patterns of station social organization. Social relations in Antarctic stations are governed by two fundamental social processes: conflict and cohesion or fission and fusion. Fusion of the social group occurs in three stages; in the first stage, the group is open to interaction among all members. Some pairs form as two persons find common interests and backgrounds. The second stage is marked by the formation of cliques, based on age and authority, occupational status and station responsibilities, religious beliefs, tastes in music, and extent of substance use. The third stage is one of coalescence where the entire group organizes around a social core.

Group fusion is marked at particular times during winter-over duty, such as during fires or other station emergencies where crew members are forced to work together for their mutual survival. It is most noticeable at the end of the winter-over period when replacements arrive. There is an almost universal sense of resentment at the outsiders who invade the station and disrupt or criticize established routines. These outsiders also provide a focus for displaced anxieties over having to once again become part of the larger society. Events such as parties may also bring individuals and cliques together in an expression of group solidarity. Finally, resentment toward outside authorities also serves to unify group members, especially since anything that can be interpeted as a sign of rejection by outside superiors "emphasizes the group's dependent status and may seriously threaten feelings of personal autonomy and competence as well as raise the men's reentry anxiety levels and unduly undermine their psychological well-being" (Natani and Shurley, 1974, p. 111).

In essense, a unified group provides an important source of social support for station members. At one station, for instance, there was an explicitly stated social norm that the community was a mutually supportive integrated whole that would deal with stress by concerted effort (Blair, 1983). Processes of social comparison, to be described later, also foster group cohesion.

However, social relations among members of Antarctic research stations are also marked by group conflicts. Conflict is inevitable at all stages of group formation. In the first stage, difficulties may arise between individuals or pairs. The second stage, as noted earlier, is marked by conflict between cliques, but even in the third stage, the social core is frequently in conflict with the isolates or peripheral cliques.

Conflicts such as these are the result of differences in sociocultural

background and occupational roles of station personnel. Historically, one particular source of social conflict has been the military vs civilian status of station members. U.S. stations have been staffed with a split command and two organizational subgroups, one scientific and civilian and the other logistic and military, each with different organizational, occupational, and career orientations. A major source of conflict at these stations has been the inherent difference between the disciplined, regulated, conservative activities of the Navy personnel on the one hand and the relatively unstructured, disorderly, independent lifestyles of the scientists on the other (Natani and Shurley, 1974).

Other sociocultural and occupational sources of conflict in Antarctic research stations have been the status of station members as superiors or subordinates (such as officers vs enlisted Navy personnel) and differences in levels of education. Navy Seabees, for instance, may be threatened by the intimate presence of personnel with superior formal education who tend to evaluate their performance using different criteria (Natani and Shurley, 1974). Different occupational subgroups, both military and civilian, are characterized by different motivation and personal values (Gunderson and Nelson, 1966) and personality traits (Gunderson and Mahan, 1966).

The failure of one or more members to adopt group norms also contributes to social fission and group conflict within a station. Personnel who are alcoholics, for instance, or personnel who refuse to participate in housekeeping chores, are held in contempt by the rest of the station members and frequently ostrasized or excluded from social activities.

Both conflict and cohesion, therefore, are inevitable features of the human experience in Antarctica. These two processes reflect the conflicting needs of the individual, who works diligently to become part of the group yet paradoxically works at the same time to keep his independence. Most persons

achieve a balance between these two needs and are able to work with and gain support from the group, yet at the same time withdraw from it (Strange and Youngman, 1971).

Nevertheless, the degree of conflict and cohesion in a confined social group may be influenced by a number of factors. One of the most important is the quality of leadership exercised within the group. The most important qualities of the leader at a small station are (1) the ability to tolerate intimacy and leveling of status without losing authority and the respect of the group, and (2) self-reliance in the lonely responsibility of command (Strange and Youngman, 1971). The importance of leadership in mitigating group conflict and maintaining a high level of morale and performance is reflected in a study of two small stations by Biersner and Hogan (1984). The station where the leader received high ratings from other station members had a highly successful winter-over period. Maintenance and technical tasks were performed at consistently high levels and social compatibility remained high during the nine months of confinement. At the second station, however, the leader received poor marks from fellow winter-over personnel; station equipment was in poor repair, technical performance met only minimum standards, conflicts among members of the group were frequent and severe, communication equipment was inappropriately used, and the station was poorly prepared for the relief party at the end of the winter period.

The heterogeneity of the social group is another factor which may influence the extent of group fission and fusion. One aspect of group heterogeneity which is increasingly becoming an issue at Antarctic research stations is the presence of growing numbers of female personnel. The status of mixed crews in space has received some attention, and while concern that the inclusion of women on long-term space missions or offworld communities will lead to jealousies as a result of crew members "pairing off" appears to be

unfounded, intolerance towards members of the opposite sex, counterproductive sexual stereotypes, attitudes, and activities, and the formation of cliques on the basis of sex are among the potential hazards that must be prevented (Harrison, 1980). Among Antarctic winter-over personnel, however, both male and female crewmembers have been supportive of mixed crews. The presence of women, in general, has not resulted in sexual jealousy or group conflicts engendered by sexual stereotypes. Nevertheless, as Oliver (1979) observes, the growth of female participation may eliminate some problems and create new ones which require solutions. Eventually, families with other sets of pressures may join these groups.

Cultural Systems of Antarctic Research Stations

A third influence on the extent of fission and fusion in social relations among winter-over personnel is the microculture of the station itself. When station personnel first arrive in the Antarctic, they represent a collection of culturally heterogeneous individuals. "Group members initially bring into the circumstances of confinement or isolation their personal life-styles, including those values, attitudes, norms, and symbol systems referent to their common and unique domains of cultural heritage" (Nelson, 1973, p. 176). Nelson also notes that:

> In addition to the diverse backgrounds and purposes for being in the Antarctic, the occupational structure of the stations is such that most of the men have had little if any previous work experience on a prolonged basis with persons of the other occupational fields. Even within the military complement of the stations, for which the Navy serves as a common referent organization, many of the traditional organizational relationships are confused by the unique combination of specialists who comprise the stations (Nelson, 1965, p. 486).

However, each station gradually develops a cultural system of its own. These "microcultures" change from year to year as personnel rotate in and out of stations; nevertheless, the cultural systems of certain stations retain a

certain amount of continuity from one year to the next. These cultural systems are a product of several different features of the human experience on the ice. One such feature is the history of that experience with its record of successes and failures. The legacies of Scott and Amundson, of Byrd and Siple, remain as part of the cultural heritage of Antarctic scientific and support personnel.

The processes of social comparison which contribute to group cohesion are another feature of the human experience in Antarctica leading to the development of station microcultures. Natani and Shurley (1974, p. 110) note that the social and leisure activities possible in the Antarctic provide "opportunities for social comparison and social evaluation that serve direct anxiety-reducing functions and inevitably lead to the formation of a new microculture adapted to this special environment."

The acknowledgment by most members of Antarctic research stations that certain norms of behavior foster individual adjustment and group adaptation also underly the development of station microcultures. Take, for instance, the norm of preservation of commons. Areas where differing groups interact are typically subject to rules that prevent friction between the groups. Expressions of this norm include the "no dirty dishes" rules in mess halls or "no outside shoes" rules that prevent visitors from adding to the residents' housework by tracking in dirt and mud. Blair (1983) states that the failure of newly arrived personnel to observe such rules at one station contributed significantly to the winter-over personnel's feelings of invasion and violation.

The behavior of station members are also governed by and evaluated in terms of other norms including cooperation, hard work, and a disdain for rash or foolhardy behavior or excessive consumption of alcohol. Within each station from one year to the next, a high value is typically placed on certain

qualities such as self-sufficiency, decisiveness, intelligence, the ability to work alone, good communication skills, assertiveness, and independence.

The social identity of station members is another feature of station microcultures. In visiting Antarctic station groups, one can observe many cultural features that over the years have differentiated groups (Nelson, 1973). Examples are the "home town" street names assigned to snow paths in a camp; the Burma Shave limerick signs alongside a snow trail leading to a station; a winter Olympics held at another station; an institutionalized pet cat at one station and the adopted indigenous penguins at another; or the initiation rituals of clubs associated with a certain station such as the Three Hundred Club at South Pole Station or the Lake Vanda Swim Club at New Zealand's Vanda Station.

Finally, station microcultures are a product of a fundamental relationship between man and nature and the need of humans to impose a cultural sense of order and meaning to an otherwise chaotic and unintelligible or unfamiliar environment. Lacking a history of human habitation until the twentieth century, Antarctica provides no referent for understanding or behavior. Pyne (1986) describes it as an information sink: "contrasts, comparisons, analogies, metaphors--all vanish before the pure immensity of the ice monolith" (p. 19). The microcultures of Antarctic research stations are an attempt to fill this void, thereby making it comprehensible and somewhat, if not entirely, habitable.

These microcultures, therefore, are a fundamental part of the processes of individual adjustment and group adaptation. As Natani and Shurley (1974, p. 97) conclude, "both science and individuals suffer when there is no common culture at the station extensive enough and sensitive enough to regulate strong counter motives, promote task accomplishment, harmonize social relationships, and rejuvenate itself when conditions demand."

Conclusion

This paper has provided a brief overview of the human experience in Antarctica, but what may be gained from this experience in terms of lessons which may be applied to the design and operation of space stations and off-world communities? For one thing, the human experience in Antarctica may suggest that prolonged isolation in an extreme environment carries with it certain behavioral and biomedical consequences. These consequences are a response to certain inherent features of this type of environment, regardless of locale. Among these features are the physical, affective, and cognitive demands of a novel environment. It is axiomatic that the physical demands placed on an individual by his or her environment is directly tied to the ability of that environment to support human life. Life support must be provided by artificial means, reducing these physical demands. Regardless of its physical severity, it is the novelty of the environment which makes it stressful in a cognitive and emotional sense. The lack of spatial-temporal orientation to an environment can disrupt the flow of information processing, resulting in confusion, anxiety, and depression.

Restricted contact and mediated communications with family, friends, and outside authorities is another feature of prolonged isolation in an extreme environment. In space, we must rely on mediated communications to link the space traveler with ground support personnel, family members, and friends. Both the medium and the manner in which information is organized and presented can influence how a message is received and the tone of exchange that follows (Conners, et al., 1986). This type of communication contributes to misunderstandings and conflicts between space traveler and ground support personnel (Kubis, 1972; Oberg, 1981). In the Antarctic, levels of depressive symptomatology have been observed to increase following radio communication with family and friends (McGuire and Tolchin, 1961).

Prolonged isolation in an extreme environment also provides few if any opportunities for certain social and psychological needs and sources of gratification. Social contacts are usually limited, nonsexual, and often marked by conflict. Privacy and sources of self-esteem are absent or must be created de novo.

Personal, social, and organizational expectations are another feature of social systems in this environment. The high priority placed on success by each of these may contribute to physical and emotional symptoms of stress.

These stresses affect all personnel to some degree. However, variations in task accomplishment, social compatability, and emotional composure of all members of a confined group are influenced by the personality characteristics of the individual; the organization of the social group, particularly as this organization is affected by the quality of leadership, ability to provide social support to individual members, and heterogeneity of its members; and the microculture of the station or offworld community, particularly the values which identify norms or rules for appropriate behavior and govern individual modes of adjustment and group patterns of adaptation and organization.

From a design standpoint, the human element in space may be influenced by altering the environment or developing programs to strengthen or enhance the processes of adaptation and adjustment to this environment. Efforts in the former area would be directed towards the design of stations and communities which (1) minimize the physical, cognitive, and emotional demands of a new and perhaps threatening external environment; (2) incorporate communications technology which allows for optimal levels of quantity and quality of interaction; and (3) provide opportunities for meeting individual needs, minimizing social conflicts, and fulfilling individual, social, and organizational expectations. Efforts are currently underway to incorporate these

individual needs and aspects of social dynamics into the design of the space station and other space facilities (Clearwater, 1987; Stuster, 1986).

Efforts may also be undertaken to develop programs to screen individuals so that those candidates who are most likely to exhibit the highest levels of adjustment are selected. Crews and residents of offworld communities may also be trained in methods and techniques which foster group cohesiveness and task performance while minimizing the potential for social conflict. Agencies and organizations participating in space ventures such as these may also take the lead in developing cultural systems specifically tailored to facilitating individual adjustment and social interaction. A model for such a cultural system has been proposed by Harris (1986) and includes ten components: (1) sense of self and space; (2) communication and language; (3) dress and appearance; (4) food and feeding habits; (5) time and consciousness of time; (6) relationships and family; (7) values and norms; (8) beliefs, customs, and traditions; (9) mental processes and learning; and (10) work habits and practices.

Whatever the design and technology available to accomplish these objectives, the human element in space will be characterized by the persistence of humankind to adapt to the rigors of prolonged isolation in extreme environments. This adaptation may be expected to occur in three phases. Phase I will involve the acquisition of information about the specific environment and the parameters imposed on human behavior in this environment. This information may come from analogs such as the Antarctic, but inevitably it must come from experience in the environment itself. Phase II will be largely programmatic in nature. It is at this juncture in the adaptation process that efforts will be made to develop technologies and organizational supports designed to facilitate adaptation in the specific environment. It is in this phase that we will witness the emergence of a nascent "space culture." Phase

III will be marked by a long-term evolutionary process of change in behavior and feedback. Patterns of behavior on space stations and offworld communities may eventually differ significantly from those observed on earth and perhaps, as Finney and Jones (1985) suggest, represent the next step in our evolution as a species.

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The human ability to adapt and perform in an extreme environment during periods of prolonged isolation is influenced by a number of social, cultural, and psychological parameters. These parameters must be taken into consideration in the design, construction, and operation of space facilities and offworld bases. This paper describes the human experience in the Antarctic and examines its relevance to the design and operation of manned space facilities and offworld communities. Scientists and support personnel who winter-over in Antarctica are subjected to a combination of physiological and psychological changes which are a response to certain inherent features of prolonged isolation in an extreme environment. Among these features are the physical, affective, and cognitive demands of a novel environment; restricted contact and mediated communications with family, friends, and outside authorities; and few opportunities for gratification of social and psychological needs. These stresses affect all personnel to some degree. However, variations in task accomplishment, social compatability, and emotional composure of a confined group are influenced by the personality characteristics of the individual, the organization of the social group, and the microculture of the station. The

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22a NAME OF RESPONSIBLE INDIVIDUAL Lawrence A. Palinkas, Ph.D.	22b TELEPHONE (Include Area Code) (619) 553-8393	22c OFFICE SYMBOL Code 30

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human element in space may be enhanced by altering the environment or developing programs to strengthen the processes of adaptation and adjustment to this environment. Space stations and offworld communities should be designed to minimize the physical, cognitive, and affective demands of the environment; incorporate communications technology which provides optimal levels of interaction with earth; and provide opportunities for meeting individual needs, minimizing social conflicts, and fulfilling individual, social, and organizational expectations. Screening programs should be focused on best qualified candidates from the standpoint of adaptation to this specific environment. Training programs designed to reduce group tension and improve performance should be encouraged. Cultural systems specifically tailored to facilitate individual adjustment and social interaction in space should be developed.